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(54) Method of making a core/pattern combination for producing a gas-turbine blade or component.

(57) Disclosed is a method of making a fused pattern/core combination for a gas-turbine blade or component. A plurality of powder layers are fused together by a laser beam in a layer-by-layer fashion to produce the pattern/core combination. The core may have thin sections having a thickness of up to about 1.524 mm (0.06 of an inch).

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This invention relates to a method of making a fused core/pattern combination for a cast gas-turbine blade or component as specified in the preamble of claim 1, for example as disclosed in US-A-4,863,538. In particular, the invention concerns a method of making a core/pattern combination for a cast gas-turbine blade or components by sequentially fusing regions of ceramic powder to form a layer of the core and adjacent thereto depositing wax or plastics material to form a region of the pattern in a layer-by-layer fashion to make a core/pattern combination.

A variety of methods are known for making ceramic cores suitable for use in producing cast gas-turbine blades. These prior-art methods include the step of covering the ceramic core with a protective coating such as an epoxy or phenolic resin to prevent the very fragile core from breaking during handling. However, the protective coating is undesirable in that it prevents subsequent mechanical work from being performed on the core, such as providing further detail or drilling holes in the core. Thereafter, the core is covered by a wax or plastics material by injection-moulding to form a pattern of the blade or component to be cast. These steps are expensive and time-consuming.

Thus, it would be desirable to provide a method of making a gas-turbine blade or component by a simple method which avoids the need to build ceramic core dies or wax-pattern dies, and eliminates the need for handling the core in a fragile state and eliminates the injection-moulding step to produce a pattern around the core.

A method of making a core/pattern combination according to the present invention is characterised by the features specified in the characterising portion of claim 1.

The present invention includes a method of making a core/pattern combination wherein the core has a configuration corresponding to a hollow portion of a gas-turbine blade or component and the pattern has a configuration corresponding to the blade or component. The inventive steps include sequentially fusing together a plurality of ceramic powder regions to form a portion of the core, and adjacent thereto fusing wax or plastics powder in regions to form a portion of the pattern, in a layer-by-layer fashion to produce a core/pattern combination. The present invention also includes a method of producing a fused core or pattern including sections having a thickness less than 0.508 mm (0.02 inches). The invention also includes a method of making a hollow gas-turbine blade using molten alloy at temperatures ranging from about 649°C (1200°F) to about 1815.5°C (3300°F).

As stated above, the invention includes a method of making a core/pattern combination by sequentially fusing together regions of ceramic material (or powder) and regions of wax or plastic powder in a layer-by-layer fashion to produce the core/pattern combination. Preferably, the layers of powder are fused together by directing a laser beam onto successive layers of powder including quartz. A suitable apparatus and method of operation for accomplishing the laser fusion of powdered material is described in U.S. patent No.4,863,538, the disclosure of which is hereby incorporated by reference. The fusing together of the powder layers may be accomplished by directing wave energy onto predetermined patterns of the powder. Such wave energy may include an electron beam.

As described in U.S. patent No.4,863,538, an apparatus useful in connection with the present invention includes a laser or other directed energy source which is selectable for emitting a beam on a target area where a part is to be produced. A powdered dispensing system deposits powder onto the target area. A control mechanism operates to selectively fuse or sinter only the powder disposed within the fine boundaries to produce the desired layer of the part. The control mechanism operates the laser to selectively sinter or fuse sequential layers of the powder, producing a completed part comprising a plurality of layers sintered or fused together. The defined boundaries of each layer correspond to respective cross-section regions of the part. The control mechanism may include a computer such as a CAD/CAM system to determine the defined boundaries of each layer. Given the overall dimensions and configuration of the part to be produced, the computer determines the defined boundaries for each layer and operates a laser-control mechanism in accordance with the defined boundaries.

The laser-control mechanism may include a means for directing the laser beam on the target area and a means for modulating the laser beam between on and off positions or a shuttering means to selectively sinter or fuse the powder in the target area to produce varying configurations as desired. The directing mechanism may operate to move the aim of the laser beam in a continuous raster scan of the target area. A modulating mechanism turns the laser beam on and off so that the powder is sintered or fused only when the aim of the laser beam is within the defined boundaries for the particular layer. The directing mechanism may aim the laser beam only within defined boundaries for the particular layer so that the laser beam can be left on continuously to sinter the powder within the defined boundaries of the particular layer.

The directing mechanism may move the laser beam in a respective raster scan of the target area using mirrors driven by galvanometers. A first mirror may reflect the laser beam to a s cond mirror

which may reflect the beam onto the target. Movement of the first mirror by its galvanometer shifts the laser beam generally in one direction in the target area. Movement of the second mirror by its galvanometer shifts the laser beam in the target area in a second direction. The mirrors may be oriented relative to each other so that the first and second directions are generally perpendicular to each other. This arrangement allows for many different types of scanning patterns of the laser beam in the target area, including a raster scan pattern.

The dispensing of the powder may be assisted by using a confinement structure which defines the outer perimeter of each layer. Each layer may be defined by a separate confinement structure or the entire part may be defined by a single confinement structure. When passages or voids in a particular layer are desirable, these may be obtained by simply not sintering or fusing the powder in the area for the void or passage. After the selective portions of the layer have been fused, the loose powder may be brushed away or blown-off to define the void or passage. Alternatively, a passage or void may be defined by placing a different type of material on top of the previous fused layer at the location of the void or passage and depositing the next loose powder layer around the insert and thereafter fusing the powder. Preferably, the insert would be constructed of material and positioned such that it may be dissolved or otherwise removed after the powder is fused together to form the void or passage.

The steps of the method of the present invention include the following. Firstly, a three-dimensional configuration of the hollow portion of a gas-turbine blade or component must be determined. Secondly, a three-dimensional configuration of the blade or component must be determined. The core may be produced by fusing together layers of ceramic powder, preferably quartz, in a layer-by-layer fashion corresponding to discrete cross-sectional regions of the hollow portion of the gas-turbine blade. A first layer of powder comprising ceramic material is deposited on a substrate in a predetermined pattern corresponding to a first cross-sectional region of the hollow portion of the gas-turbine blade. The first layer of powder is fused together by directing a laser beam over the predetermined pattern of the first layer of ceramic powder to form a first fused layer of ceramic having the shape of the first cross-sectional region of the hollow portion. Likewise, the pattern may be produced by fusing together r gions of wax or plastics material, which may be deposited adjacent the ceramic powder or fused ceramic, and in a manner consistent with forming each layer of the core. A second layer of ceramic powder is deposited on the first layer of fused c ramic or fused wax or plastics material in a second predetermined pattern corresponding to a second cross-sectional region of the hollow portion which is immediately adjacent to the first cross-sectional region. The second layer of powder is fused together by directing a laser beam over the second predetermined pattern to form a second fused layer of ceramic having the shape of the second cross-sectional region of the hollow portion, and so that the second fused layer is fused to the first fused layer. The second layer of the pattern is formed in a similar fashion as described above. Successive layers of powder are deposited onto previous fused layers in predetermined patterns corresponding to respective cross-sectional regions of the hollow portion of the core and of the pattern. Each of the successive layers of powder is fused together to form successive fused layers, wherein each of the successive fused layers are fused to a previously fused layer to form the core having a configuration corresponding to the hollow portion of the gas-turbine blade or component, and a pattern having a configuration corresponding to the blade or component.

The core/pattern combination may be used to make a gas-turbine blade. A readily removable casting mould is placed around the pattern and the core so that it conforms to the outer surface of the pattern. The wax or plastics pattern may be removed in a manner known in the art, such as preheating the wax pattern or dissolving the plastics pattern. Molten alloy is poured into the casting mould so that the molten alloy fills the mould, and the molten alloy is thereafter solidified. The cast moulding may be broken away and the core removed with molten caustic soda.

Preferably, the ceramic powder comprises quartz. The quartz may comprise alpha or beta quartz. All powders will have an average particle size under 100 micrometres. When the quartz powder is alpha/beta quartz, a core made therefrom can withstand the casting of a molten alloy having a temperature ranging from about 649 °C (1200 °F) to about 1815.5 °C (3300 °F).

The wax or plastics powder used to produce the pattern may have a similar size and configuration. Each layer of fused pattern may have a thickness of about 0.254 to 1.524 mm (0.010 to 0.06 inches).

Claims

1. A method of making a core/pattern combination by sequentially depositing layers of a fusible powder upon a substrate and sequentially fusing said layers together by means of a laser beam, characterised in that said method comprises the steps of: depositing a first layer of powder comprising a ceramic material onto

said substrate in a predetermined pattern corresponding to a first cross-sectional region of a hollow portion of a gas-turbine blade or component; fusing together said first layer of ceramic powder by directing said laser beam over the predetermined pattern of said first layer of powder to form said fused layer of ceramic having a shape of said first cross-sectional region of said hollow portion; depositing a first layer of powder comprising at least one selected from the group consisting of wax and plastics material on said substrate in a predetermined pattern corresponding to a first cross-sectional region of said blade or component; fusing together said first layer of wax or plastics powder by directing a laser beam over the predetermined pattern corresponding to said first cross-section of blade or component to form a fused layer of wax or plastics material having a shape corresponding to said first cross-sectional region of said blade or component; the fused regions of ceramic material and the fused regions of wax or plastics material of the first layer forming a first fused layer; depositing a second layer of ceramic powder onto said first fused layer in a second predetermined pattern corresponding to a second cross-sectional region of said hollow portion which is immediately adjacent said first cross-sectional region of said hollow portion same; fusing said second layer of ceramic powder by directing a laser beam over said second predetermined pattern of said hollow portion to form a second fused layer of ceramic material having the shape of said second cross-sectional region of said hollow portion, and so that said second fused layer of ceramic material is fused to said first fused layer; depositing a second layer of wax or plastic powder onto said first fused layer in a second predetermined pattern corresponding to a second cross-sectional region of said blade or component which is immediately adjacent to the first cross-sectional region of said blade or component; fusing said second layer of wax or plastics material by directing a laser beam over said second predetermined pattern of said blade or component to form a second fused layer of wax or plastics material having the shape of said second cross-sectional region of said blade or component, and so that said fused layer of wax or plastics material is fused to said first fused layer; and depositing successive layers of powder onto previous fused layers of ceramic material or fused layers of wax or plastics material in predetermined patterns corresponding to a respective cross-sectional regions of said hollow portion and said blade or component, and fusing ach of said successive layers of powder to form successive fused layers, wherein each of said successive fused layers is fused to a previous fused layer to form said core having a configuration corresponding to said hollow portion of said gas-turbine blade and a pattern having a configuration corresponding to said blade or component.

2. A method according to claim 1 in which said ceramic powder comprises quartz.

3. A method according to claim 1, in which said core has sections having a thickness less than 1.524 mm (0.06 of an inch).

4. A method of making a gas-turbine blade or component according to any one of claims 1 to 3, in which the method includes placing a readily-removeable casting mould around said pattern and core, which casting mould conforms to said pattern; removing said pattern to leave a void; pouring a molten alloy into said casting mould to fill said void; solidifying said alloy; removing said casting mould; and removing said core with liquid caustic soda.

5. A method according to claim 4, in which said molten alloy has a temperature ranging from about 649 °C (1200 °F) to about 1815.5 °C (3300 °F).

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 93200117.5

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	EP - A - 0 089 155 (ROLLS-ROYCE LTD) * Claims 1-6,13,21,23 * --	1-4	B 22 F 5/04
A	EP - A - 0 115 092 (BBC AKTIENGESELLSCHAFT BROWN, BOVERI & CIE) * Claims 1-3 * --	1-4	
A	EP - A - 0 166 940 (MTV MOTOREN- UND TURBINEN-UNION) * Claims 1-3,8,9 * ----	1-4	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

B 22 F 5/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	16-03-1993	BRUS

CATEG RY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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